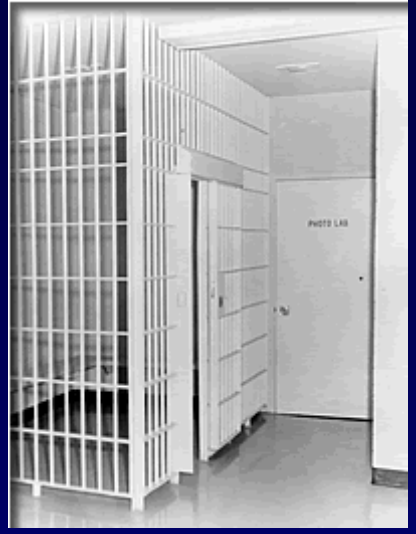
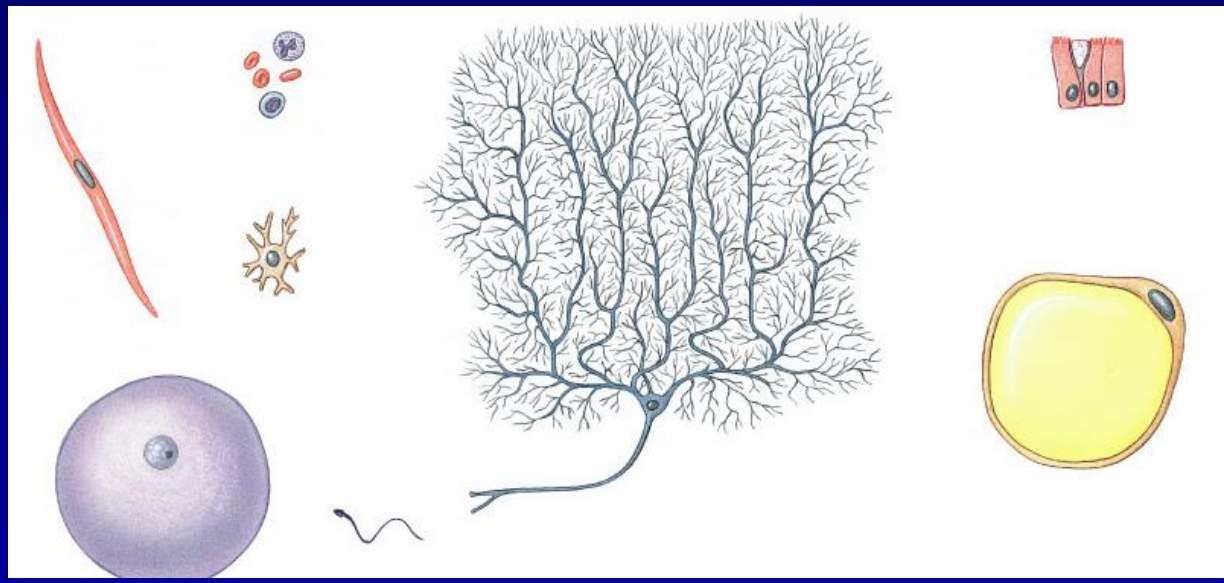
Ch 2: The Cell



Goals:

- Anatomy of a typical cell
- Cell Membrane
- Discussion of internal structure of a cell with emphasis on the various organelles



Developed by
John Gallagher, MS, DVM

LAS POSITAS COLLEGE

Some Terminology:

1. Cells are the smallest living structure
2. Cell = functional unit of the body
3. Cytology = The Study of Cells
4. Ultrastructural Cytology = Cytology at the Electron Microscopic level
5. Histology = the study of tissues (next meeting)

Anatomy of a typical cell

1. Cell membrane
2. Cytoplasm
   = cytosol + organelles
3. Organelles

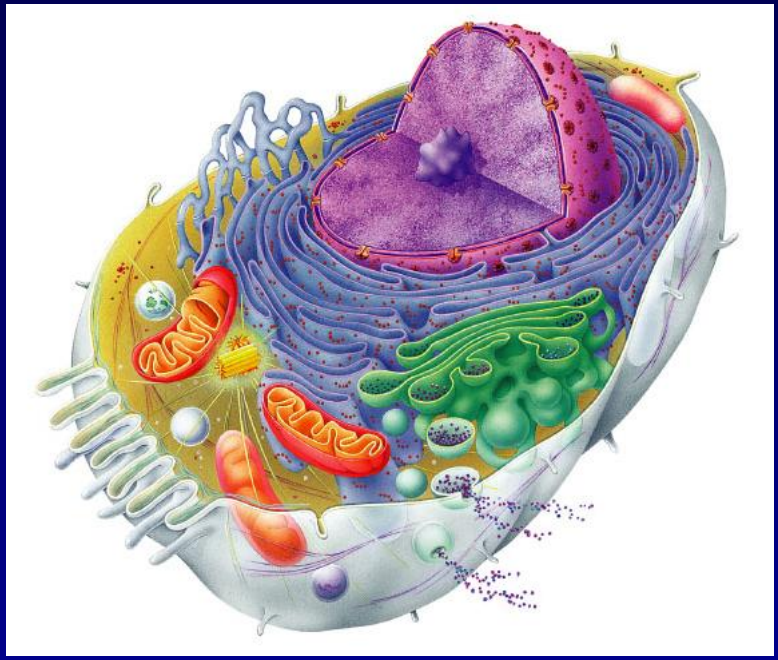


Fig. 2.1

- Smallest:
  - Granule cell in cerebellum: 4 μ
  - RBC: 5-7 μ = 0.005-0.007 mm
- Largest:
  - Anterior horn cell in spinal cord: 135 μ
  - Ovum: 120 μ = 0.12 mm
- Longest:
  - Pseudounipolar cell (CNS to toe)

Anatomy of a typical cell, cont'd

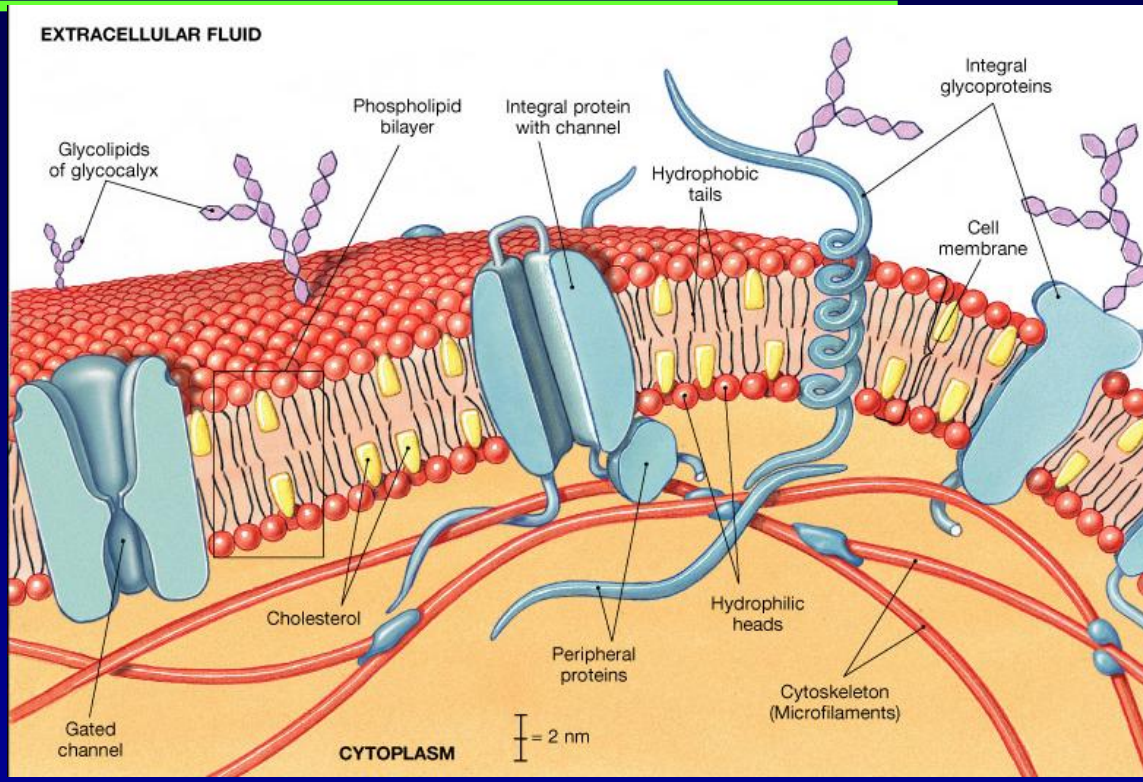
- Shapes:
  - Squamous (scale) - flat, capillaries, lungs
  - Cuboidal - lines ducts
  - Columnar - length > width, digestive tract
  - Stratified - many layers
  - Many others will be covered in histology (next two lectures)

Cell Membrane = phospholipid bilayer

- Physical isolation of the cell contents from the environment (interstitium)
- Regulation of exchange of materials with the environment
- Sensitivity to changes in the environment
- Structural support of the cell
  - Organelles, too!

Cell Membrane

Synonyms:
- plasma membrane
- plasmalemma
- axolemma
- others

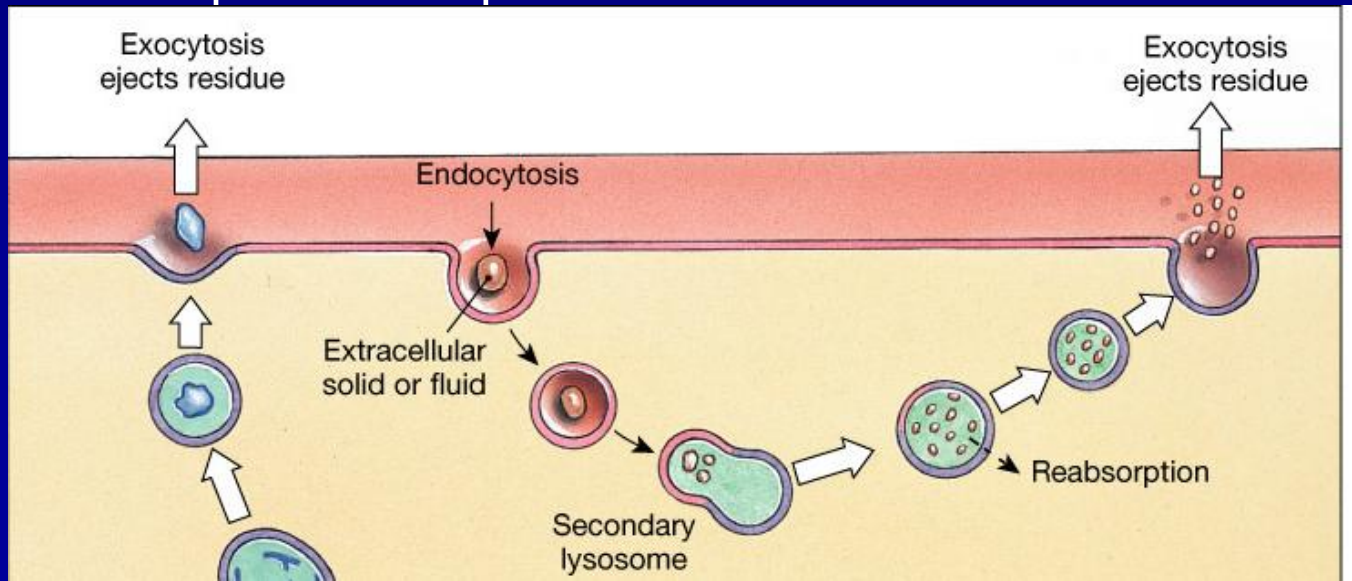


Membrane Permeability

- Diffusion
  - Concentration Gradient of Solutes
- Osmosis
  - Water (solvent) through semipermeable membrane
- Filtration
  - Hydrostatic Pressure
    - » Capillaries!
- Active Transport
  - Requires energy (ATP)

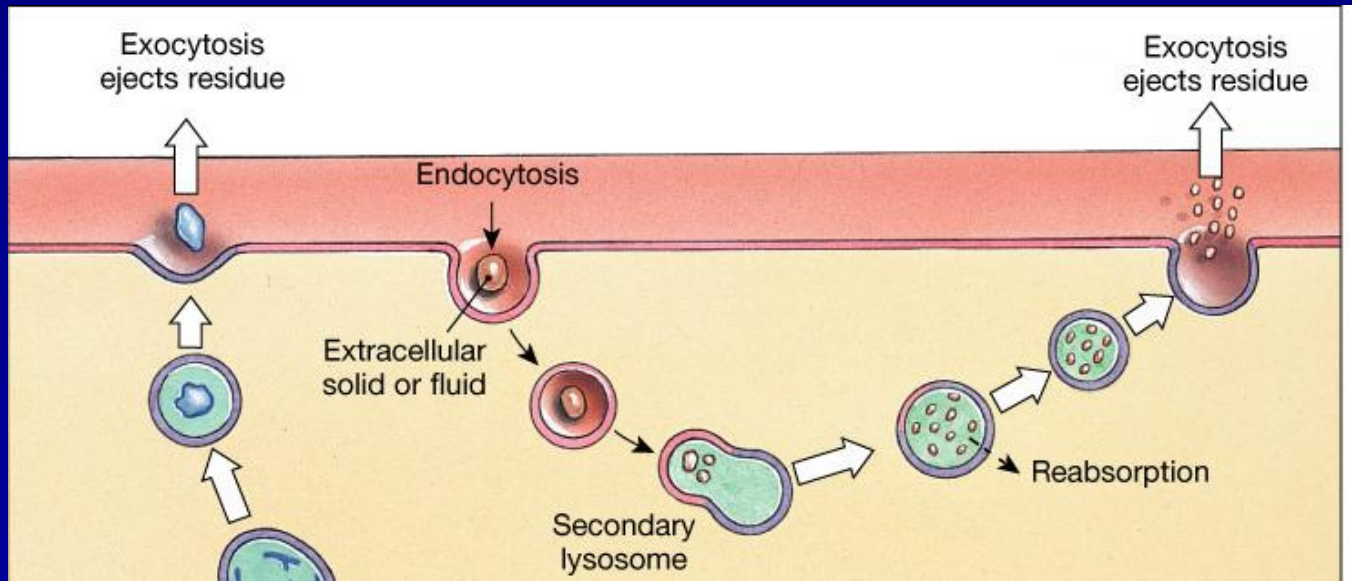
Endocytosis = into the cell

- Pinocytosis
  - Extracellular Fluid
- Phagocytosis
  - Solid Objects, e.g., bacteria
- Receptor-mediated Endocytosis
  - Special membrane proteins required



Exocytosis = out of the cell

- Secretory vesicles (e.g. hormones)
  - Fluid and waste removal

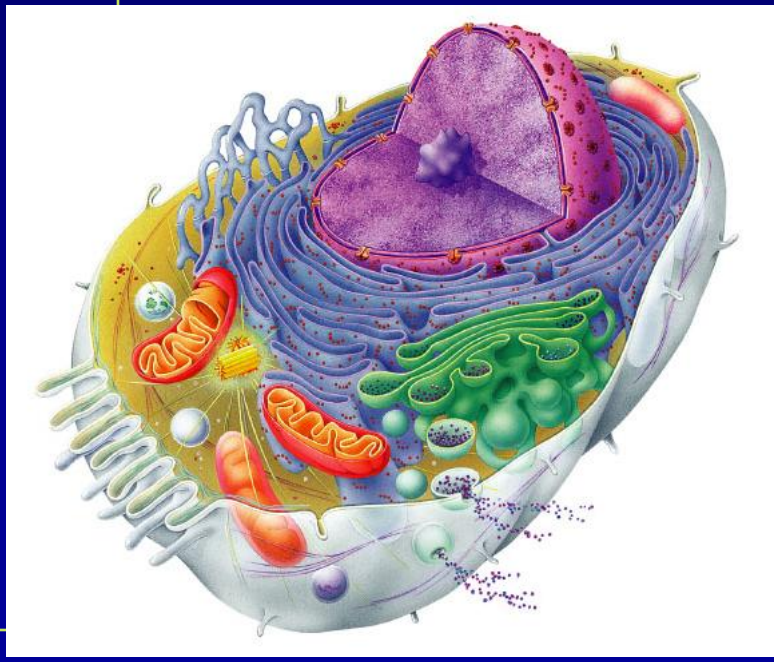


Cytosol vs. cytoplasm

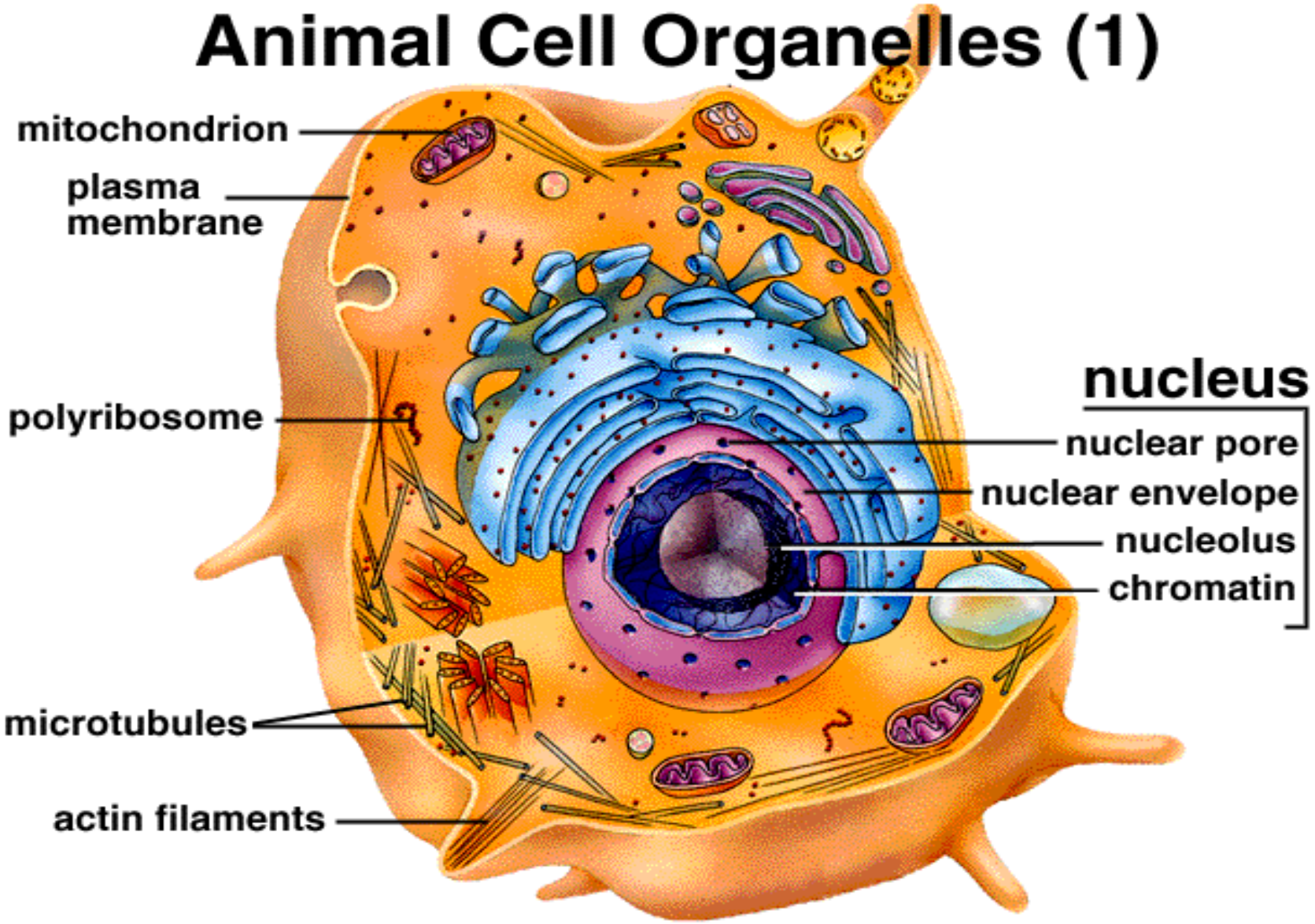
- Cytosol = The thick fluid inside any cell
- Often synonymous with cytoplasm (protoplasm)
  - Cytoplasm = cytosol + organelles
- Suspends organelles

Organelles

- Structures INSIDE a cell that have specific functions wrt cellular structure, maintenance, or metabolism
  - Membranous
    - » Nucleus
    - » Golgi apparatus
    - » Endoplasmic reticulum
    - » Mitochondria
    - » Vesicles and lysosomes
  - Nonmembranous
    - » Ribosomes
    - » Microtubules (cytoskeleton)
    - » Actin/Myosin in muscle cells



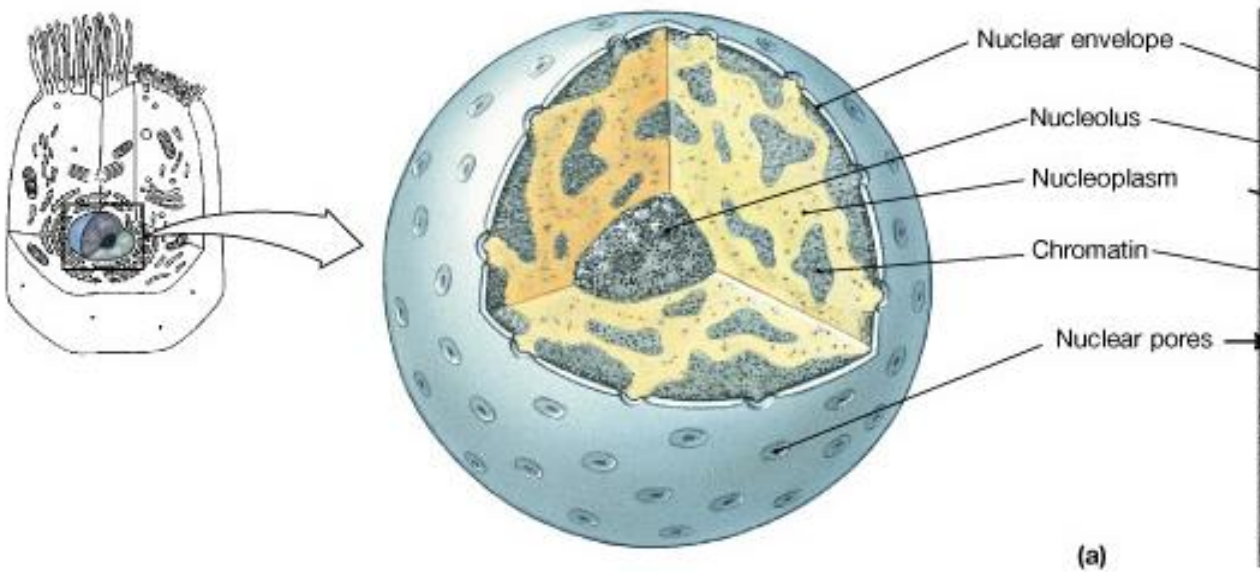
Animal Cell Organelles (1)

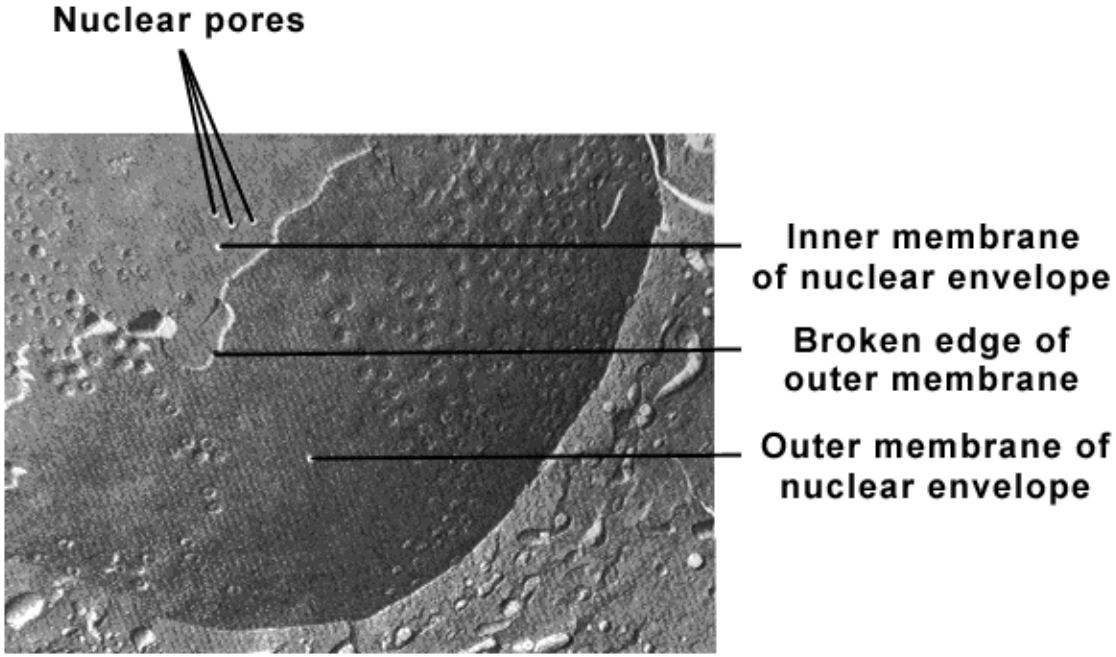


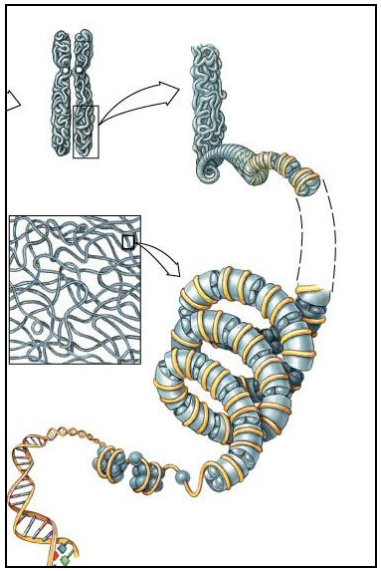
Nucleus (= center)

- Visible with LM
- Membrane bound
  - Many pores
- DNA
  - 23 Pairs of Chromosomes
    - » Except gametes
- Nucleolus
  - Most active DNA

Nucleus

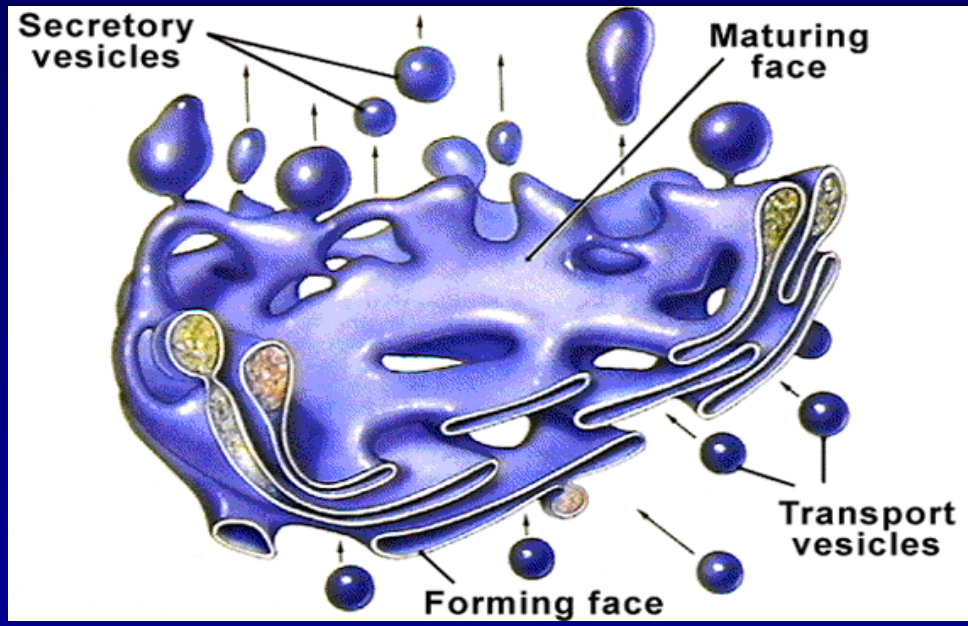

Nuclear envelope
Nucleolus
Nucleoplasm
Chromatin
Nuclear pores
(a)


Nuclear pores
Inner membrane of nuclear envelope
Broken edge of outer membrane
Outer membrane of nuclear envelope



Golgi Apparatus

- Packaging and shipping of proteins (secretory granules and transport vesicles)
- Membrane renewal
- Synthesis of Lysosomes



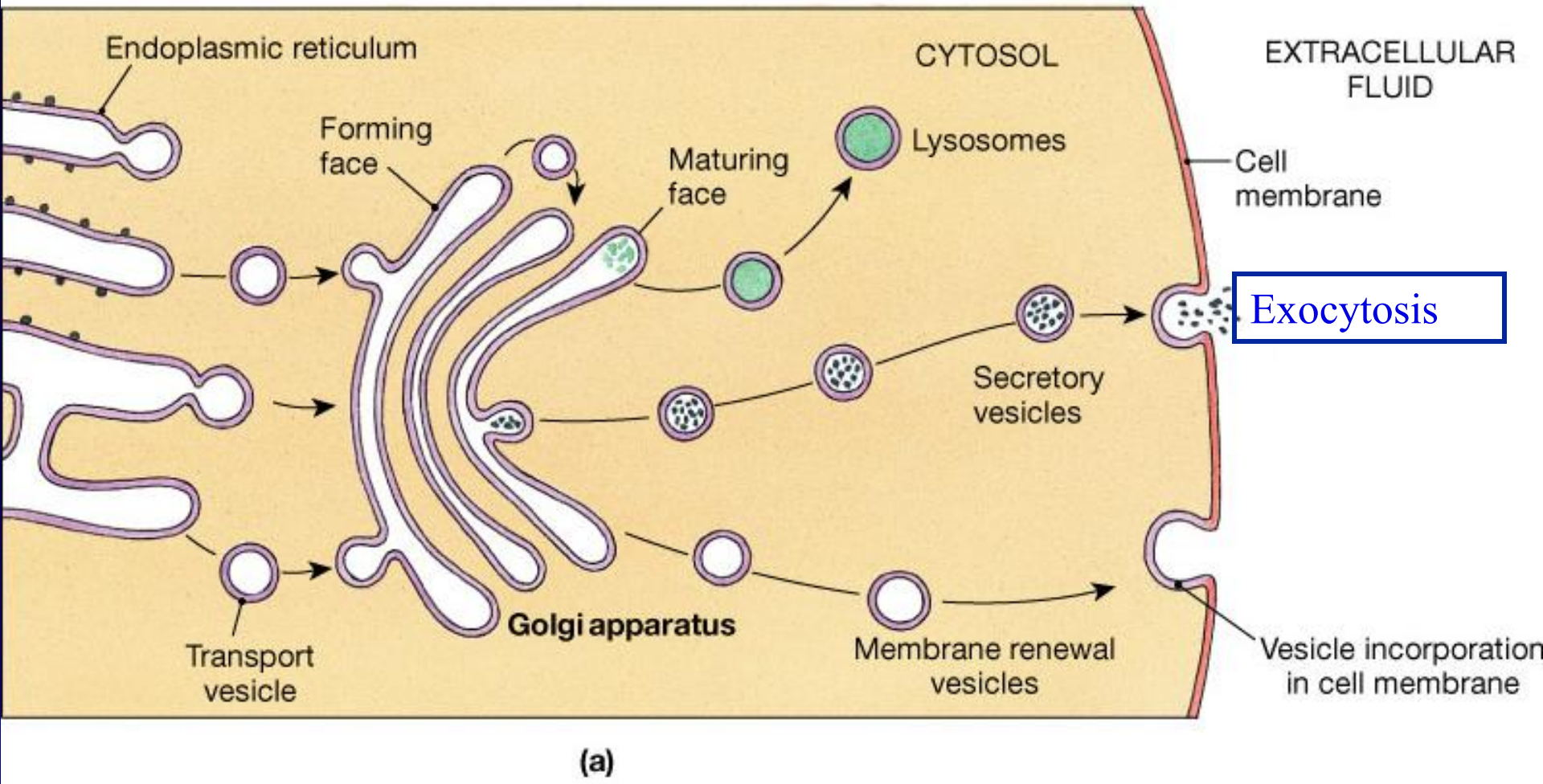
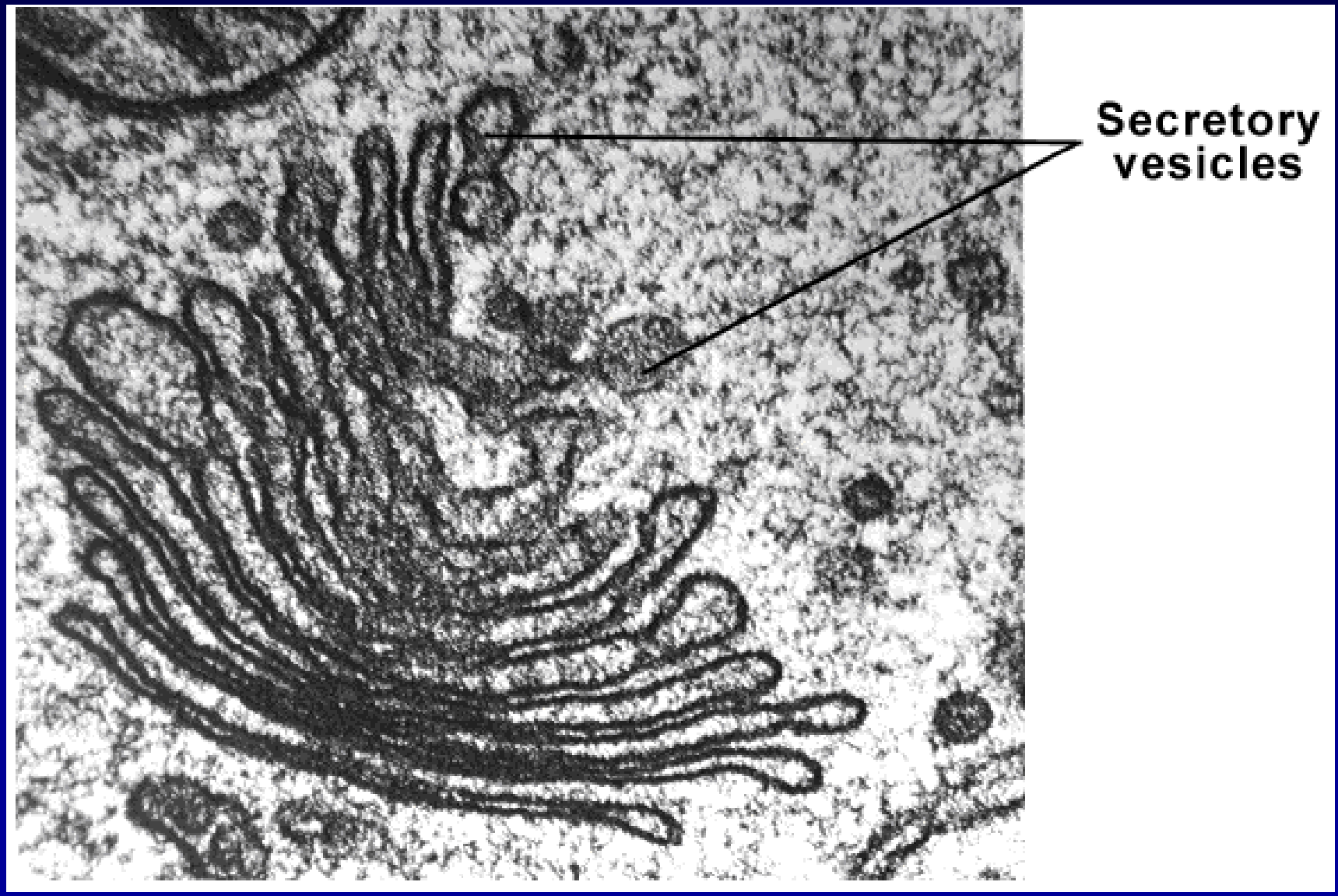

Endoplasmic reticulum
CYTOSOL
EXTRACELLULAR FLUID
Forming face
Maturing face
Lysosomes
Cell membrane
Exocytosis
Secretory vesicles
Transport vesicle
Golgi apparatus
Membrane renewal vesicles
Vesicle incorporation in cell membrane
(a)

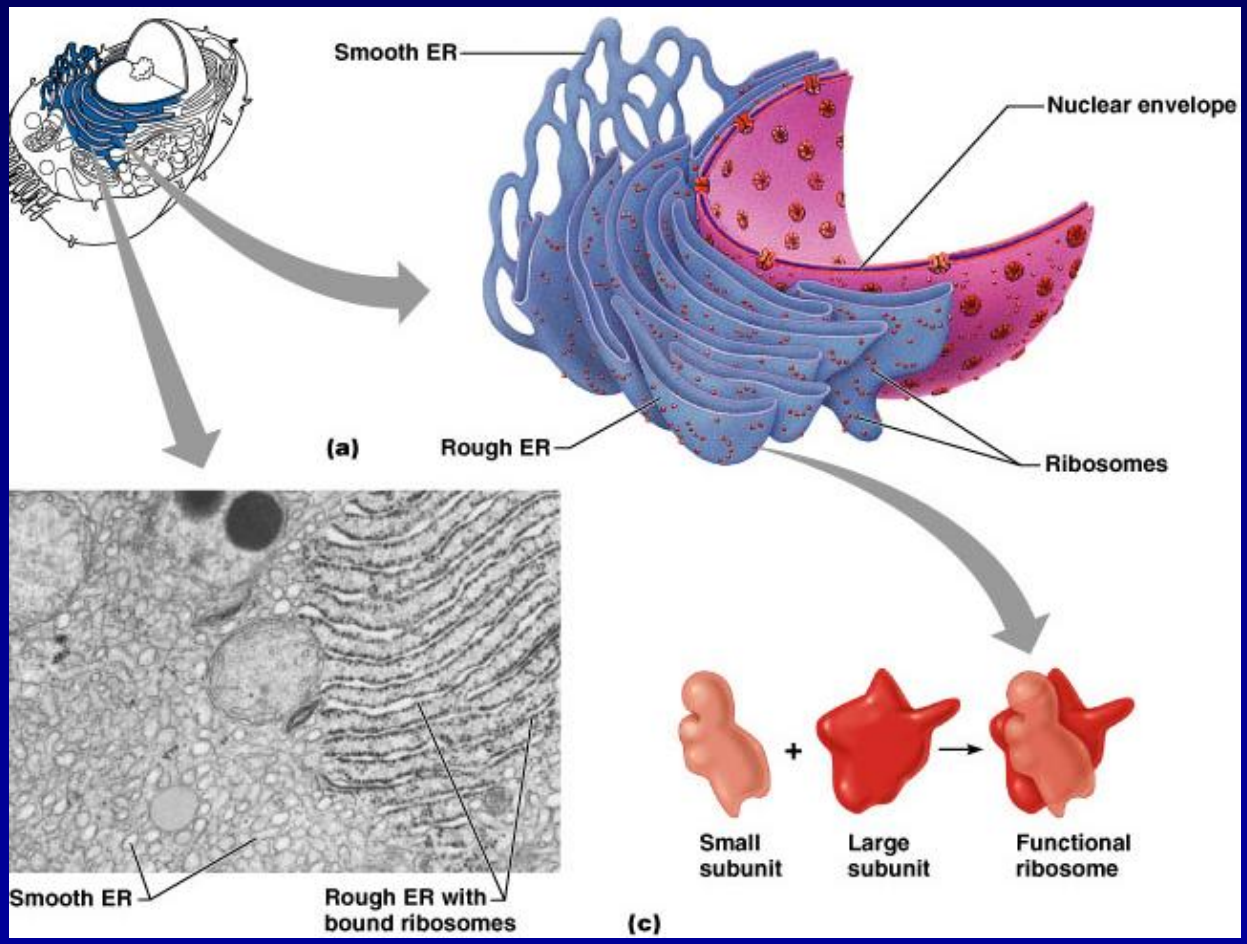
Fig 2.17

Golgi Apparatus



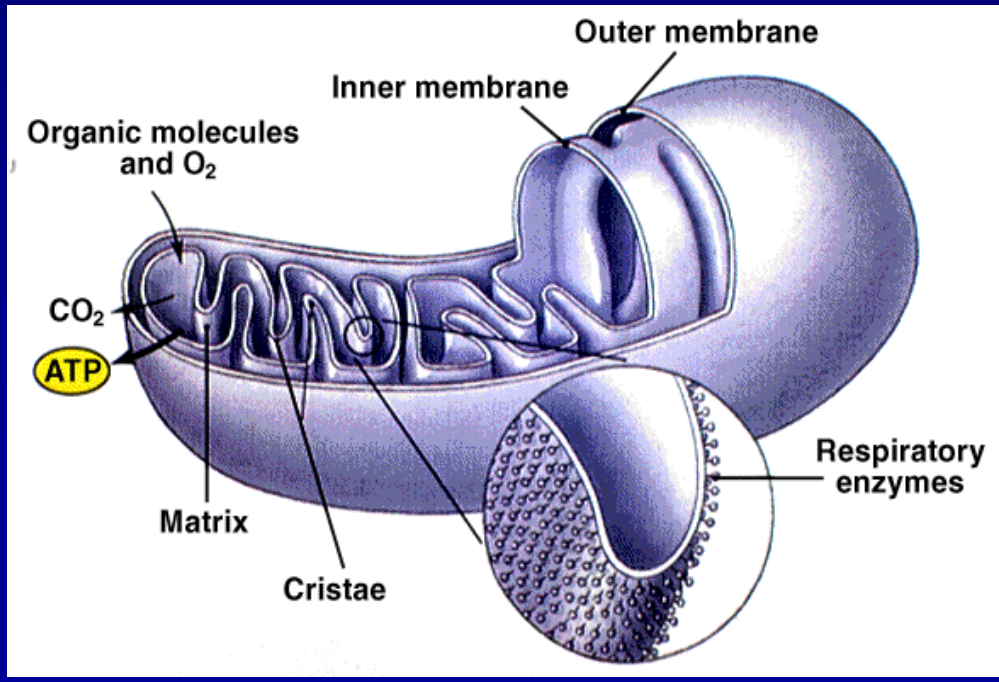
Endoplasmic Reticulum

- Synthesis, Storage, transport
- Smooth ER
  - Lipid synthesis
- Rough ER
  - Ribosomes make it rough ER
  - Protein synthesis

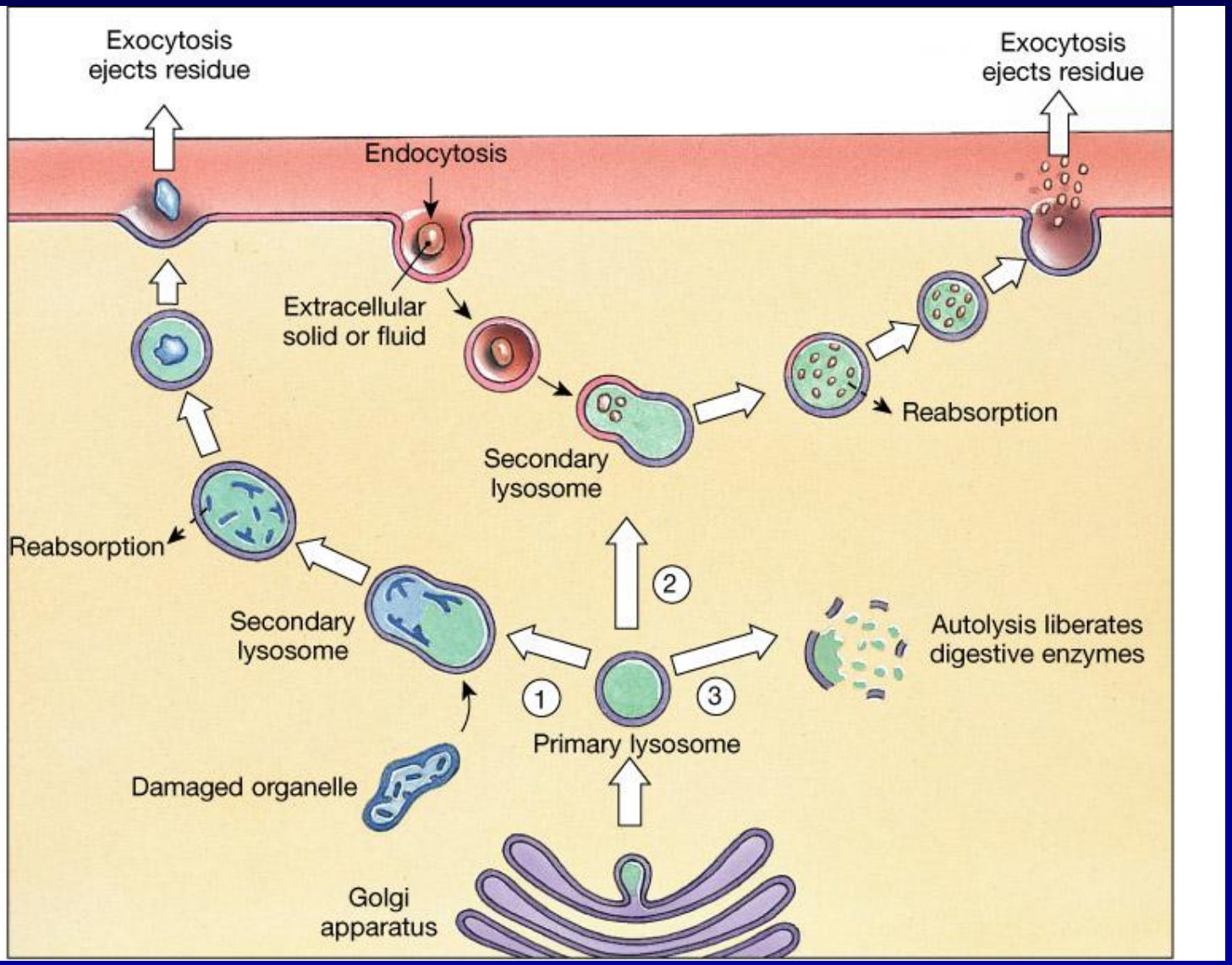


Mitochondrion / -a

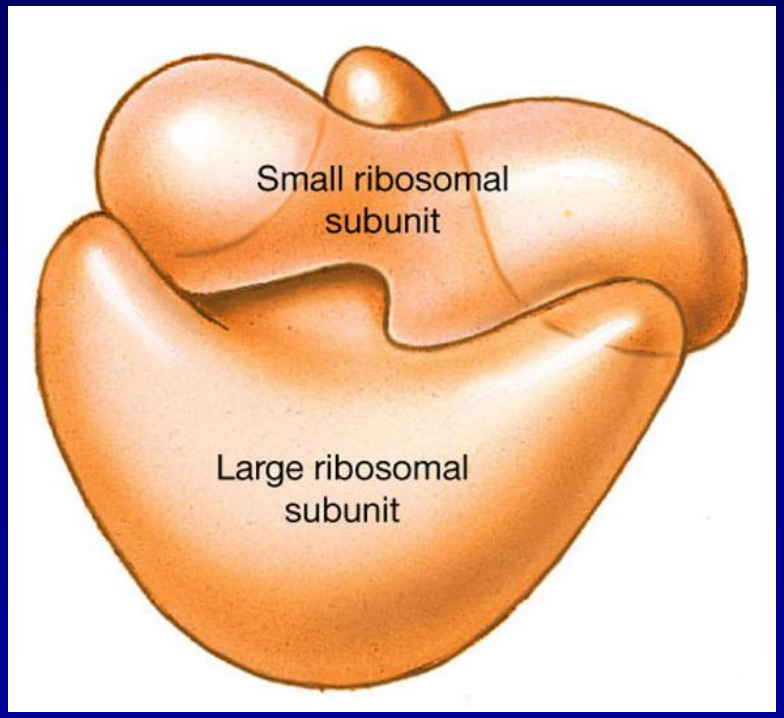
- Energy Conversion for cellular activities
  - Formation of ATP
- Double membrane
  - Glycolysis and TCA cycle
- More prevalent in active cells, e.g. rods and cones
- Their own genome
  - Self-replicating

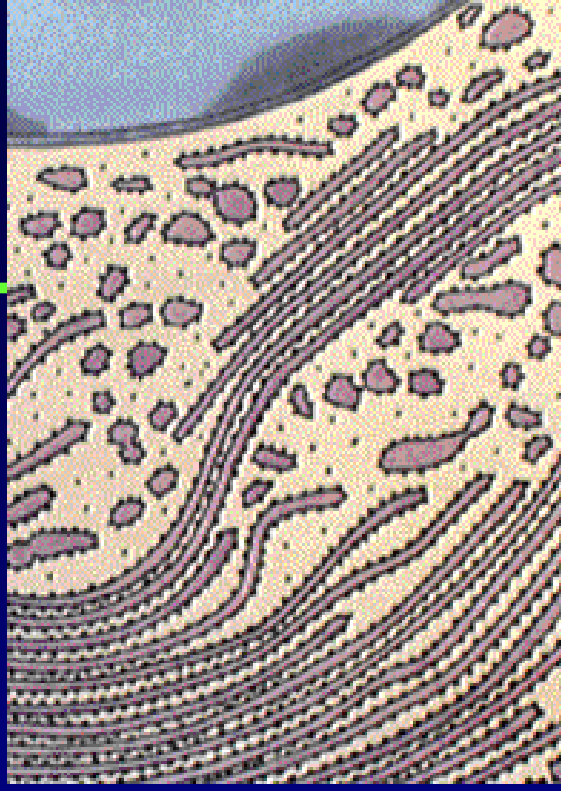


Lysosomes


Exocytosis ejects residue
Endocytosis
Exocytosis ejects residue
Extracellular solid or fluid
Reabsorption
Secondary lysosome
Reabsorption
Secondary lysosome
2
Autolysis liberates digestive enzymes
1
3
Primary lysosome
Damaged organelle
Golgi apparatus

Ribosomes - RNA





60% RNA + 40% protein

Protein Factories

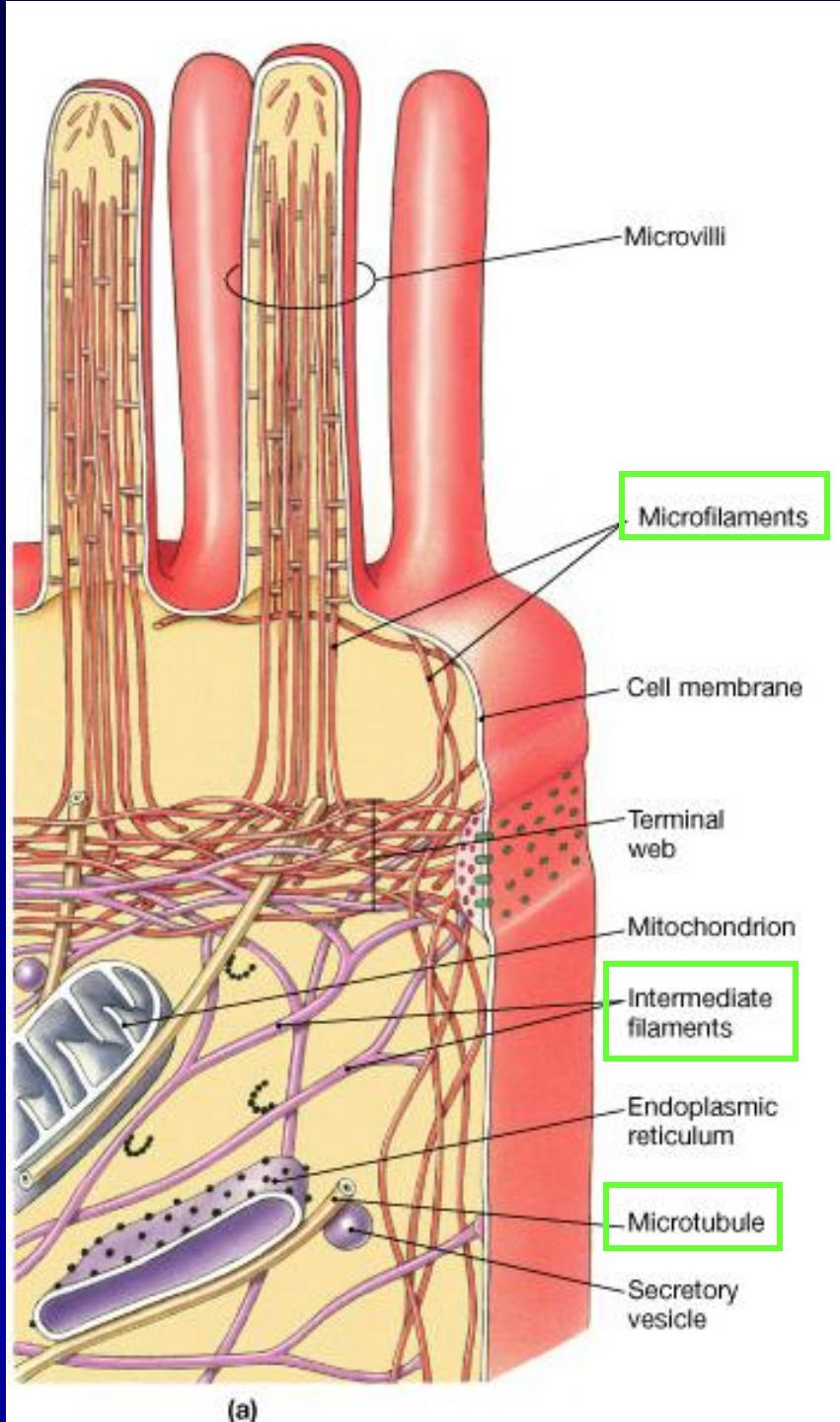
Fixed vs. free ribosomes

Cytoskeleton

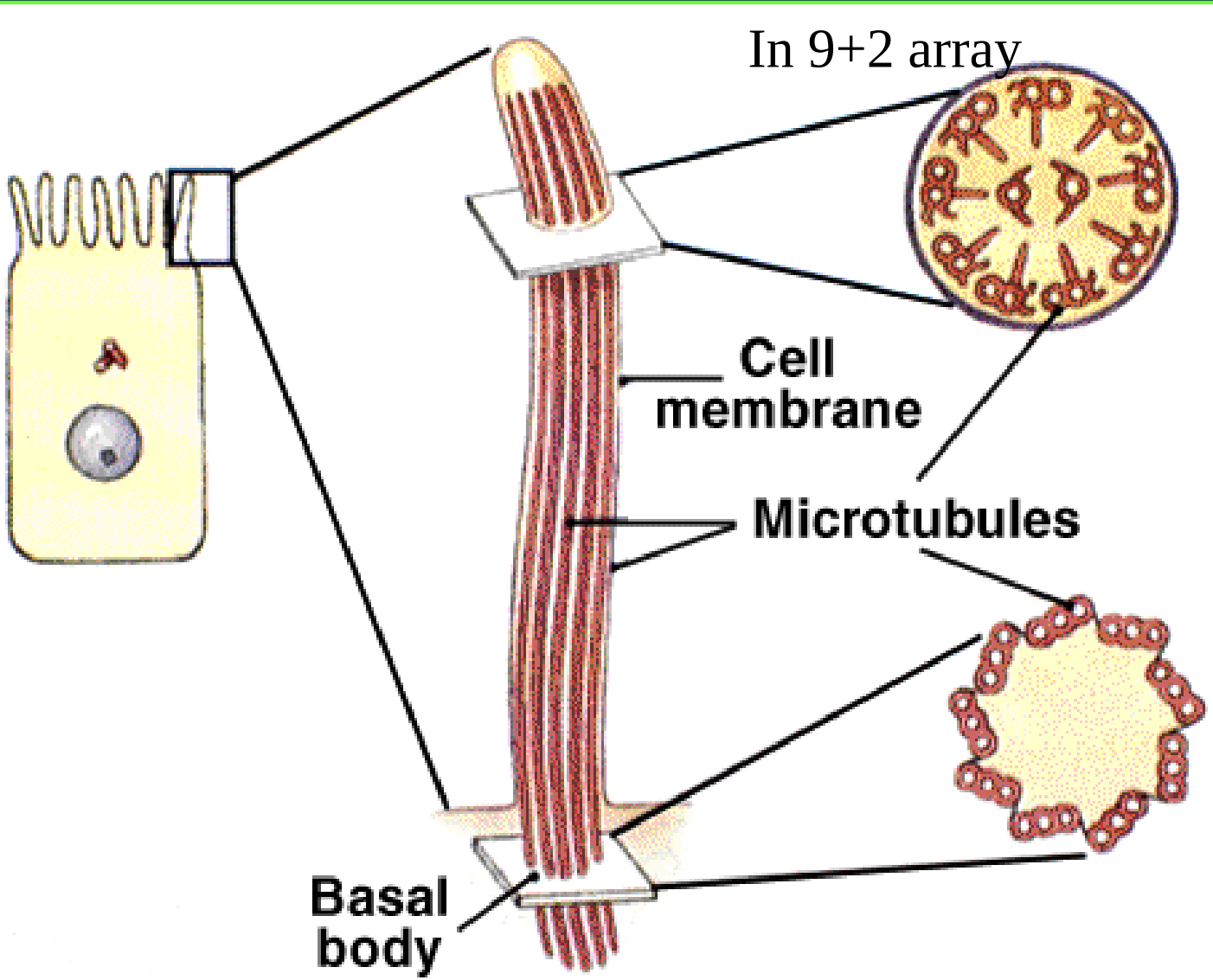
4 major components:

1. Microfilaments (mostly actin)
2. Intermediate filaments
3. Microtubules (composed of tubulin subunits)

Function: support & movement of cellular structures & materials



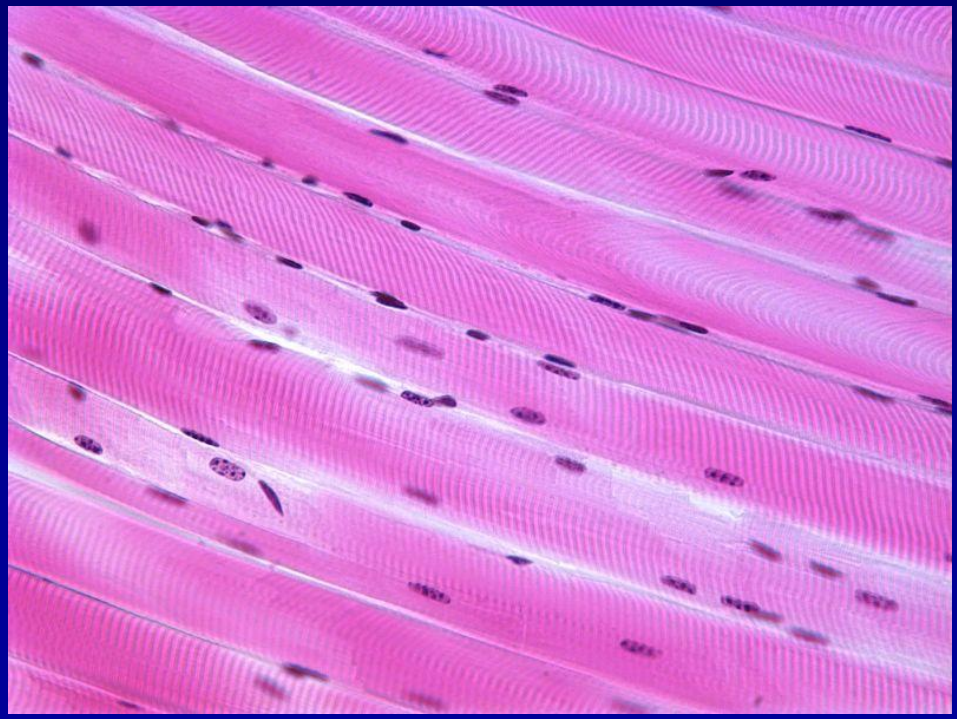
Cilium – Cilia (pl.)



Compare to microvilli and flagella

Actin/Myosin

- The contractile proteins in muscle cells
- Striations



Skeletal muscle

Intercellular Attachments
Chapter 4, pp 74-76

Act as:

1. Seals betw cells
2. Intercellular communication
3. Added strength to resist separation

1. Gap Junctions
2. Tight Junctions
3. Desmosomes
4. Basement Membrane

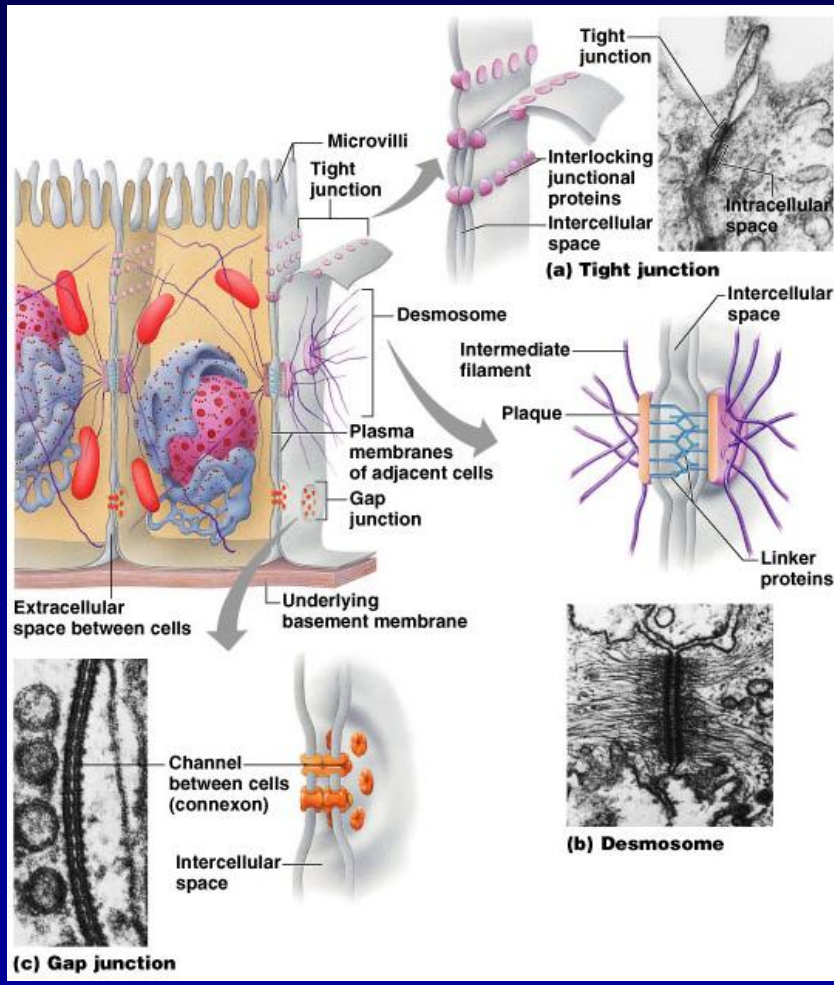
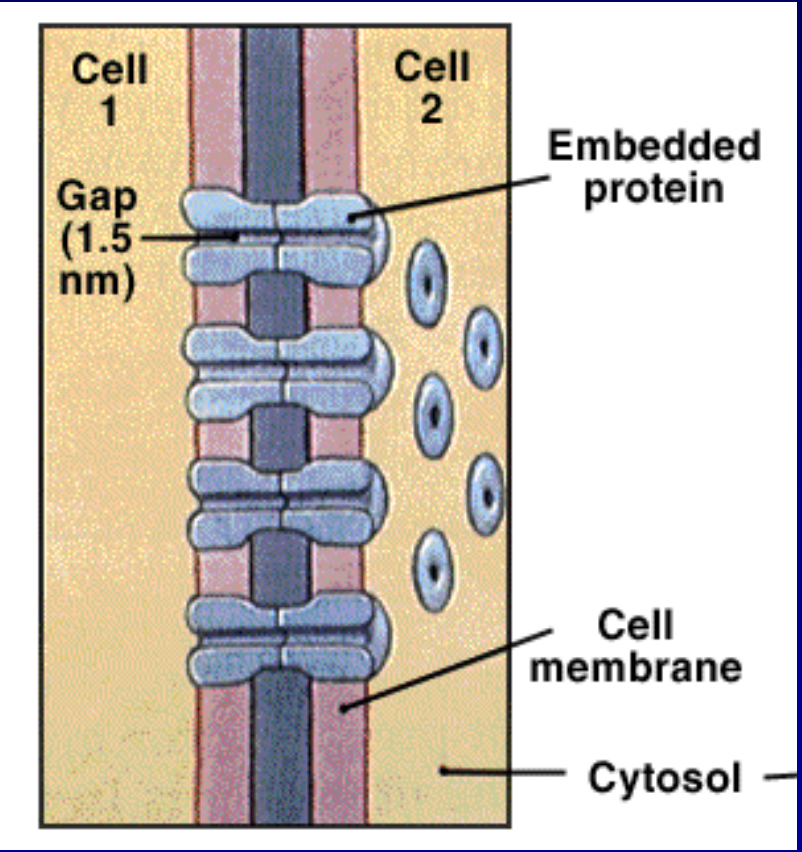


Fig 4-7

1) Gap Junctions

- Channel proteins (connexons) interlock and form pores
- Abundant in cardiac and smooth muscle
- Allows efficient intercellular communication

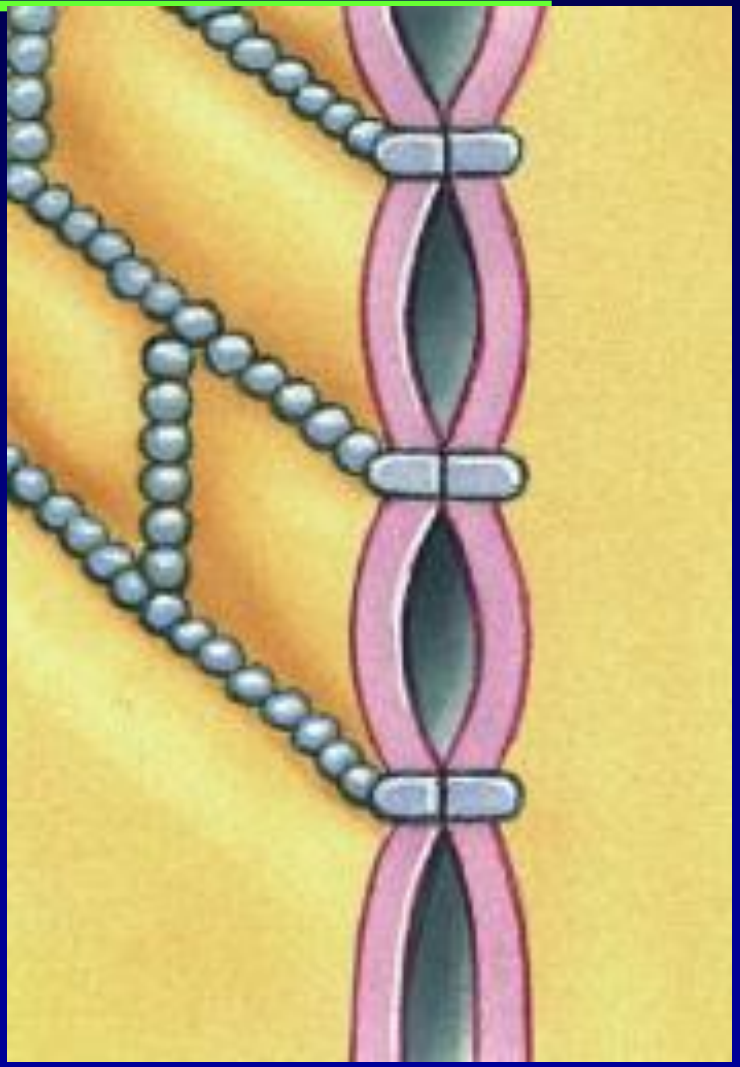


2) Tight Junctions

Interlocking membrane proteins

Found near surface of cells lining the digestive tract. *Explain!*

Adhesive Belt Junctions deep to tight junctions reinforce the seal

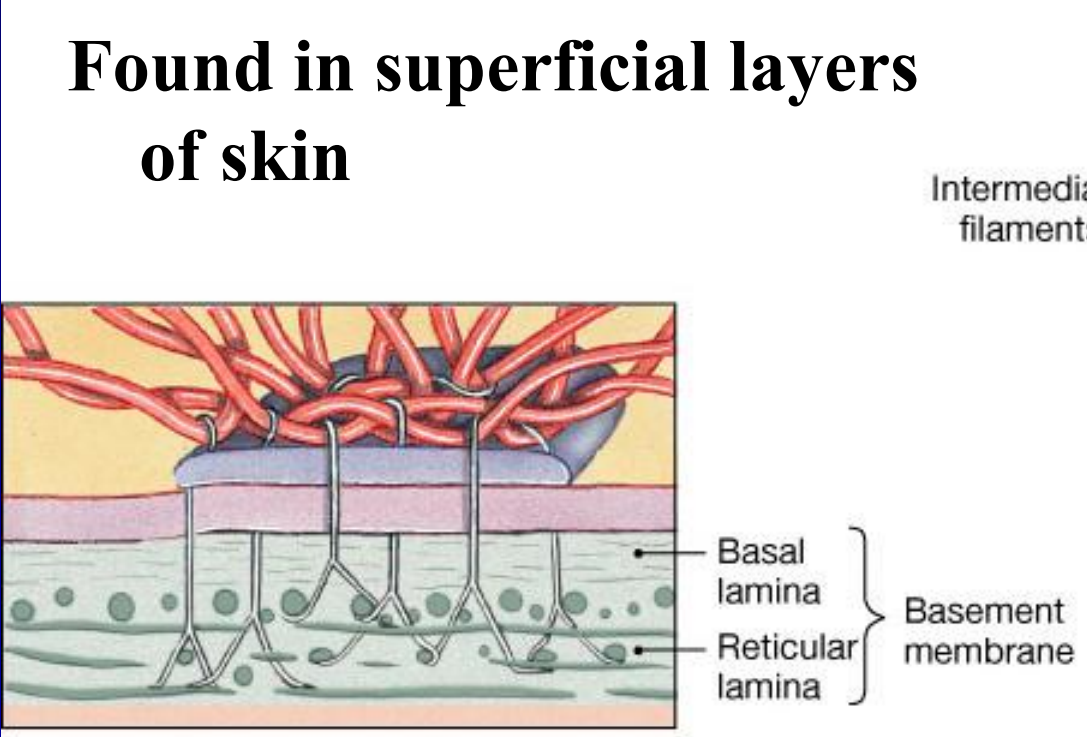


3) Desmosomes

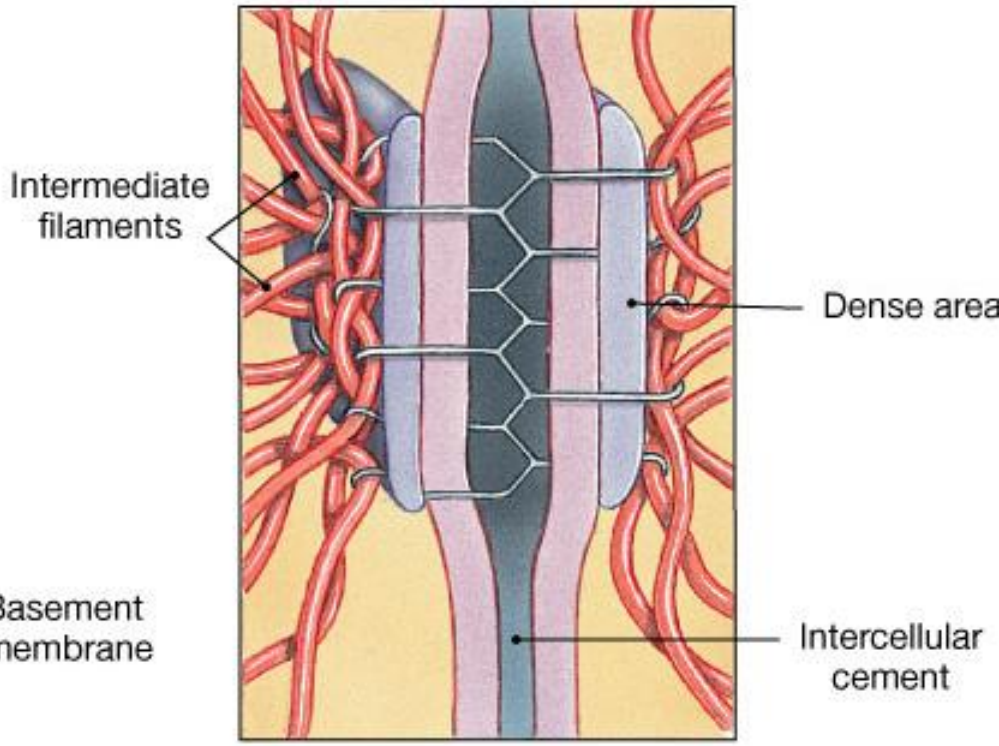
Proteoglycan layer reinforced by transmembrane proteins (cell adhesion molecules or CAMs)

Belt, button and hemidesmosomes

Found in superficial layers of skin



(e) Hemidesmosome



(d) Desmosome

4) Basement Membrane

- Reticular fibers + Basal Lamina
- Between epithelium and deeper connective tissue
- Acts as a filter, and helps epithelial regeneration

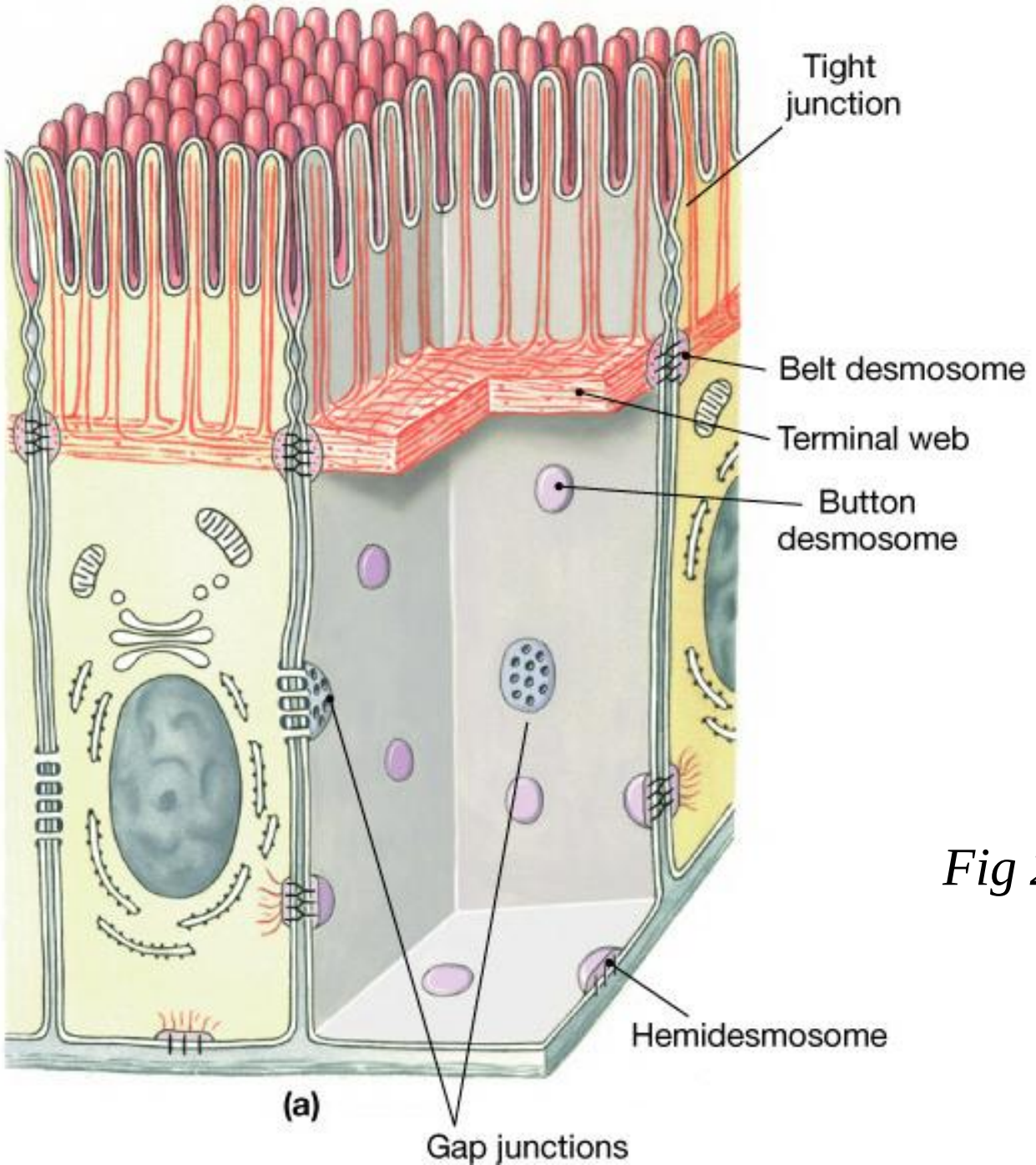
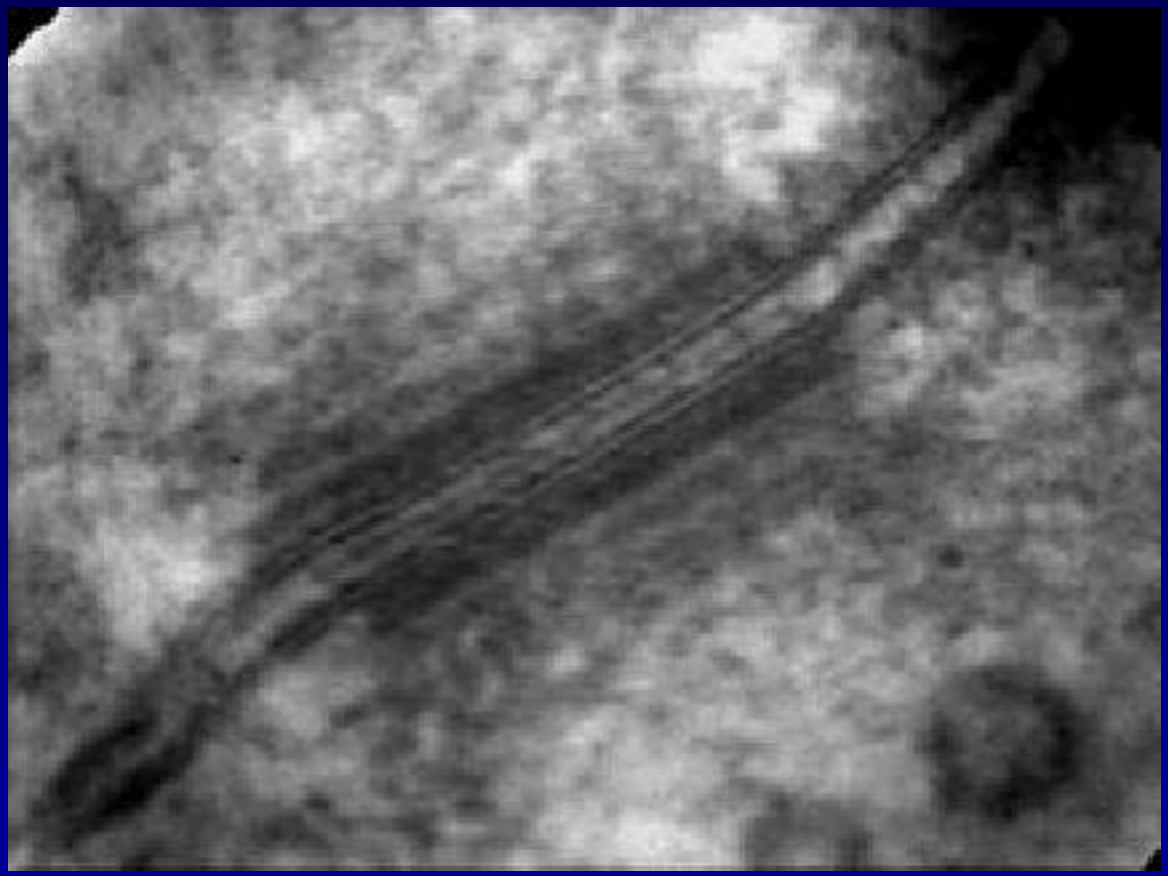

Tight junction
Belt desmosome
Terminal web
Button desmosome
Hemidesmosome
(a)
Gap junctions

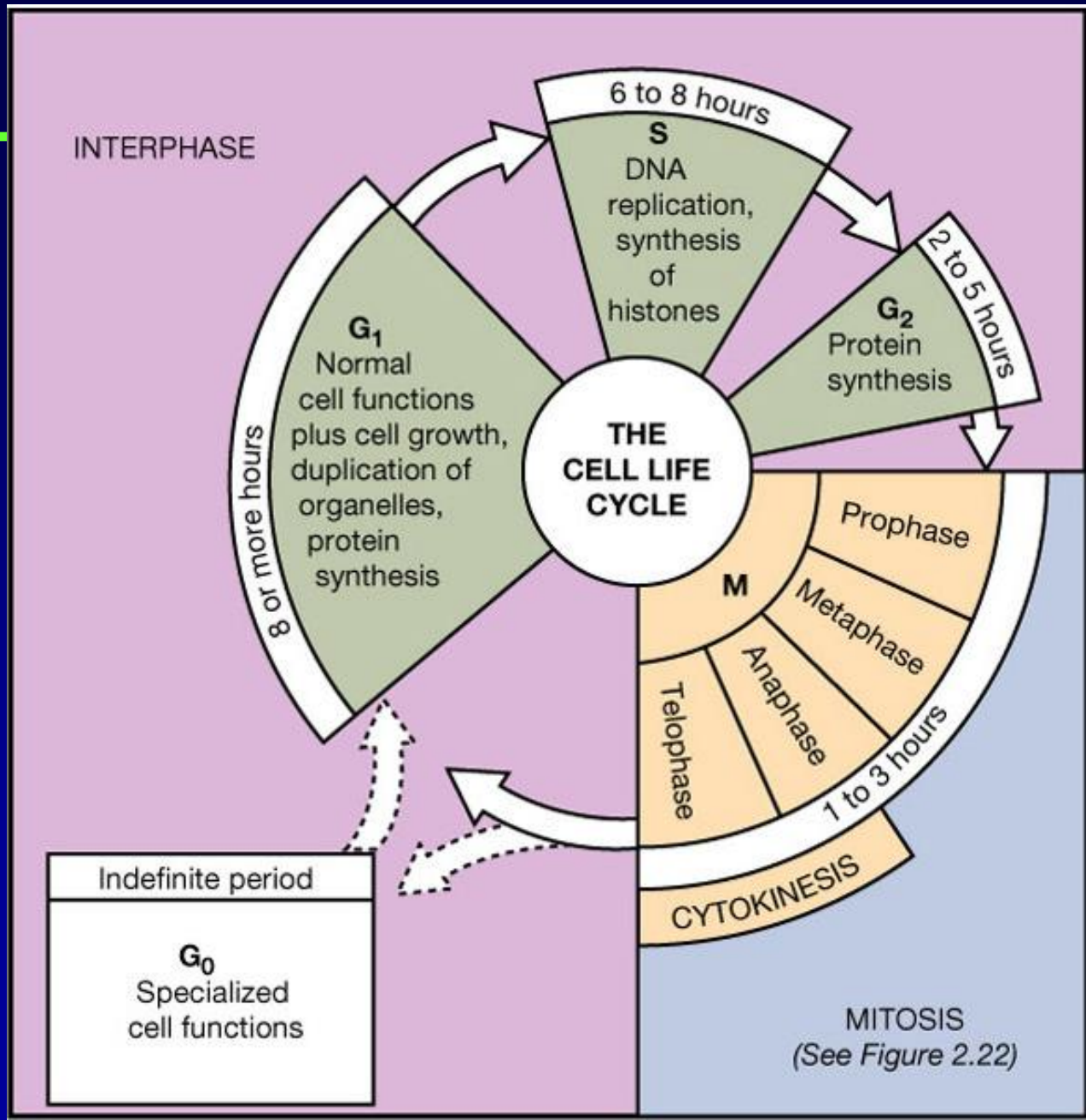
Fig 2.19 a

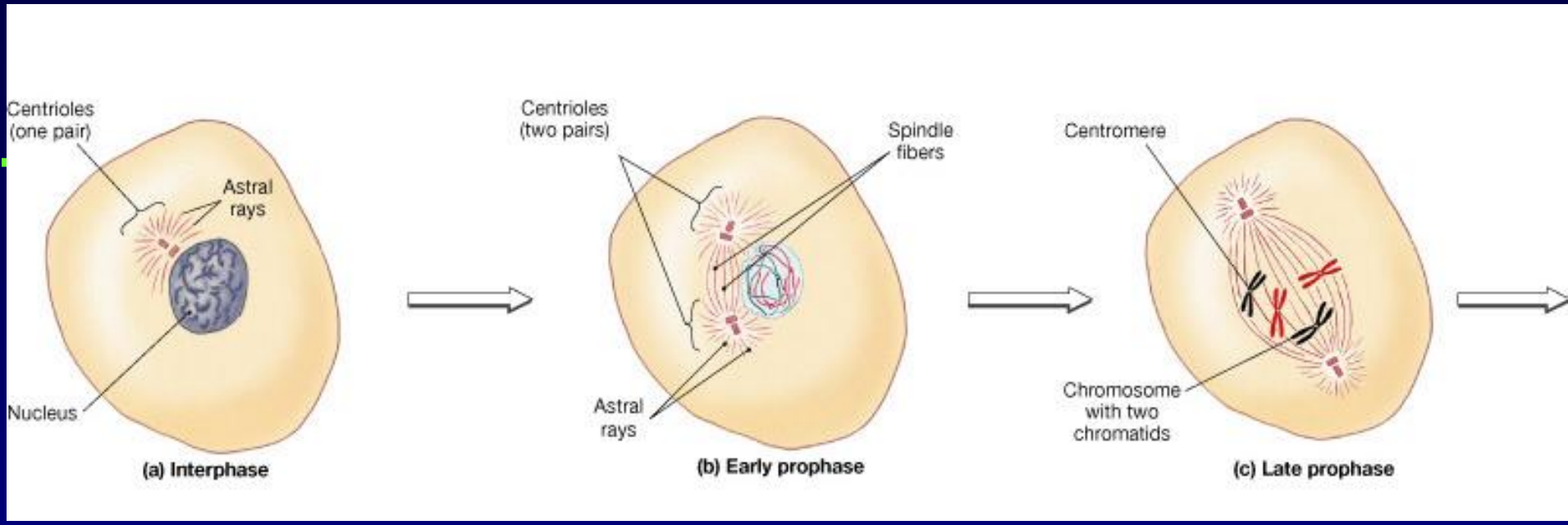


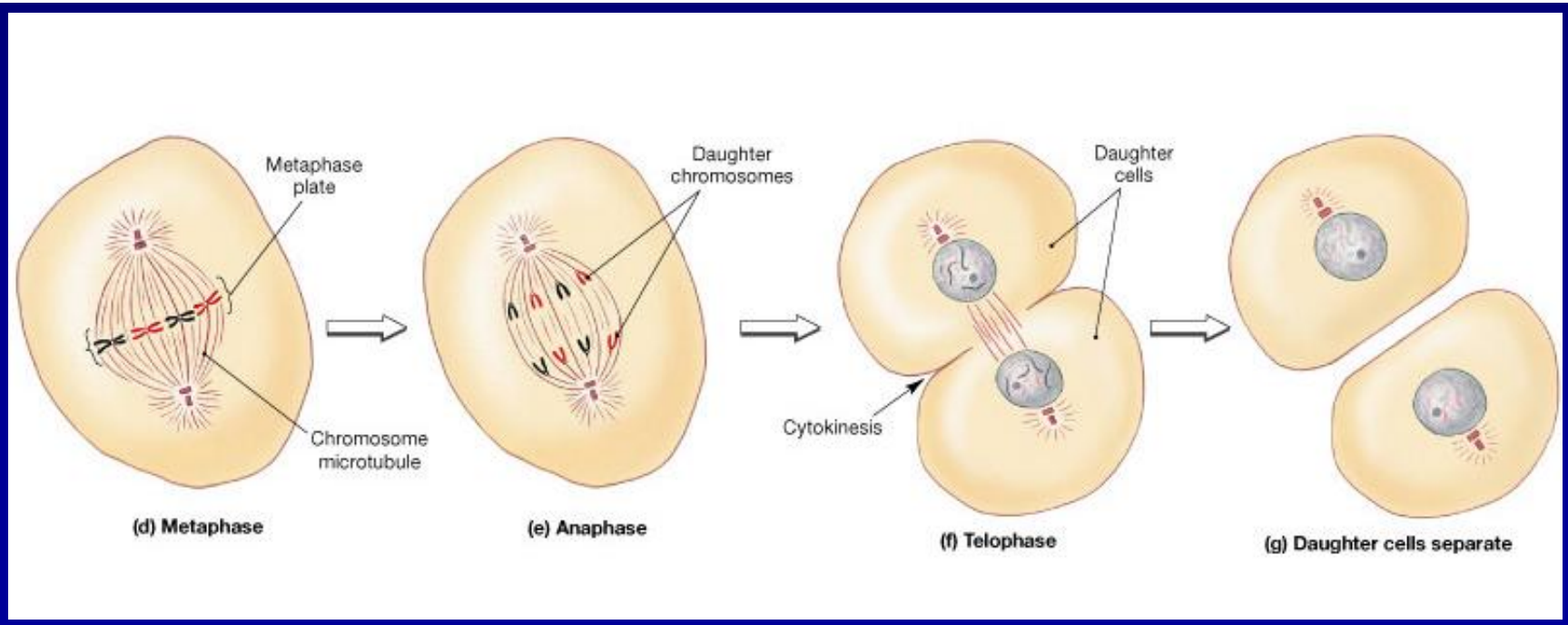
Mitosis (vs. meiosis)

- Cell Division
  - Interphase – Between mitosis
  - Prophase – Chromosomes become bunched
  - Metaphase – Chromosomes gather at equator
  - Anaphase – Chromosomes move to poles
  - Telophase – The two new nuclei form
  - Cytokinesis – Actual cell separation
  - Two new diploid cells

Mitosis


INTERPHASE
6 to 8 hours
S
DNA replication, synthesis of histones
2 to 5 hours
G_2
Protein synthesis
THE CELL LIFE CYCLE
G_1
Normal cell functions plus cell growth, duplication of organelles, protein synthesis
8 or more hours
M
Prophase
Metaphase
Anaphase
Telophase
1 to 3 hours
CYTOKINESIS
Indefinite period
G_0
Specialized cell functions
MITOSIS
(See Figure 2.22)

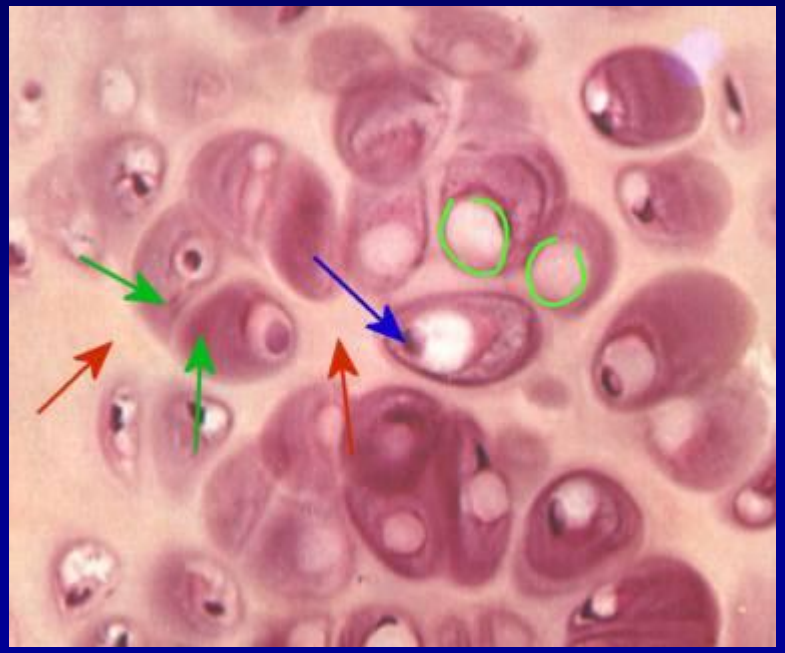

Centrioles
(one pair)
Astral
rays
Nucleus
(a) Interphase
Centrioles
(two pairs)
Spindle
fibers
Astral
rays
(b) Early prophase
Centromere
Chromosome
with two
chromatids
(c) Late prophase


Metaphase
plate
Chromosome
microtubule
(d) Metaphase
Daughter
chromosomes
(e) Anaphase
Daughter
cells
Cytokinesis
(f) Telophase
(g) Daughter cells separate

Some cells

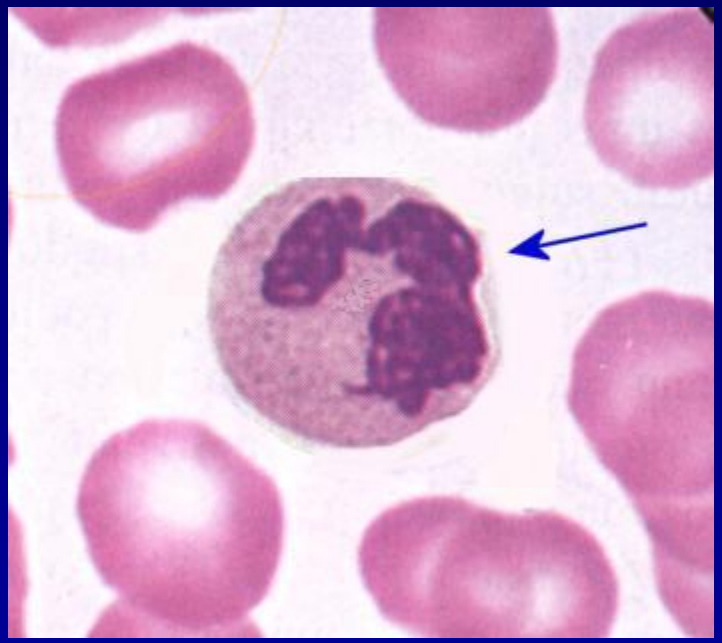
Fat cells (adipocytes)

Cartilage cells (chondrocytes)

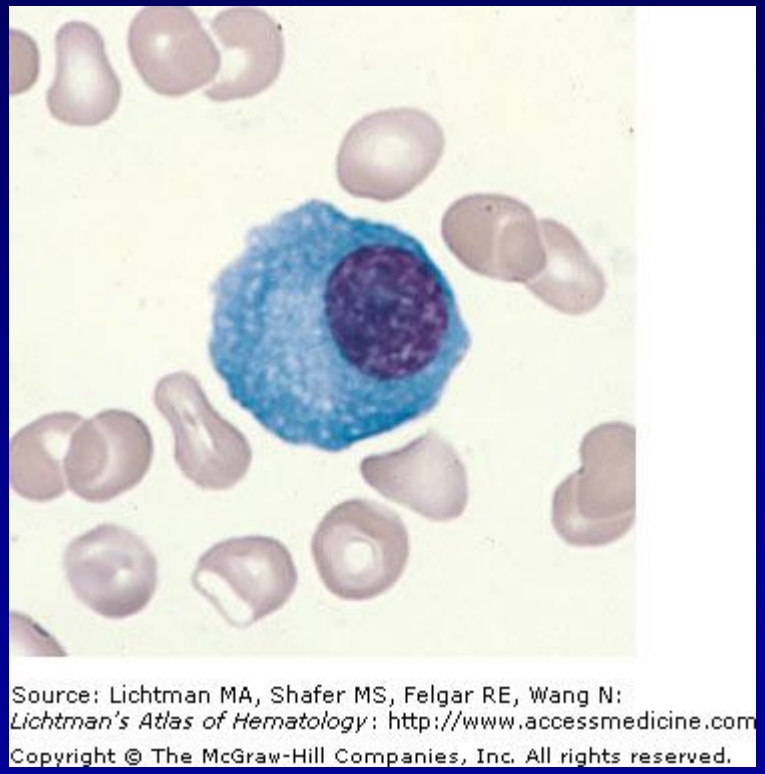


More cells

Neutrophil



Plasma cell

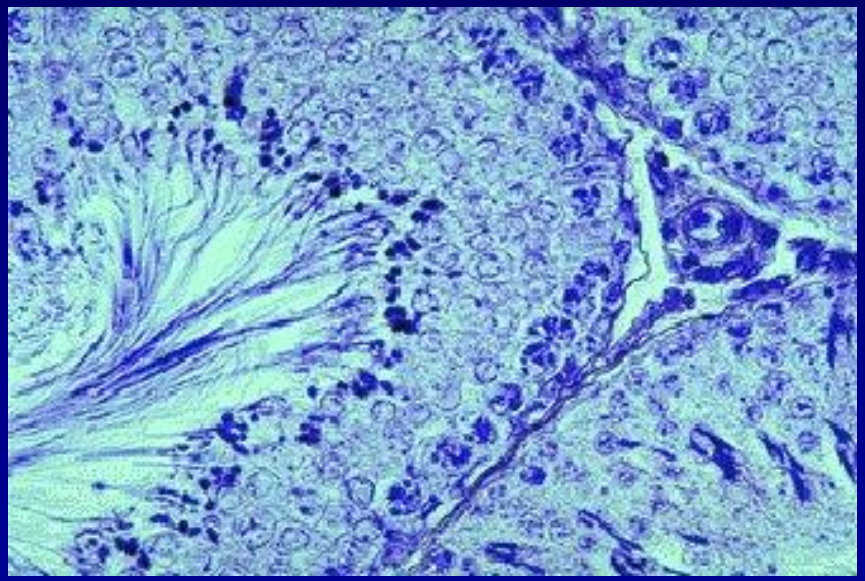


Source: Lichtman MA, Shafer MS, Felgar RE, Wang N:
Lichtman's Atlas of Hematology: http://www.accessmedicine.com
Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

Still more cells

Columnar cells

Sperm cells (spermatozoa)



River Cullenagh, Ennistymon, Co Clare, Ireland